PATENT SPECIFICATION

602,795

Convention Date (United States of America): March 23, 1942.

Application Date (in United Kingdom): May 10, 1943. No. 7375/43.

Complete Specification Accepted: June 3, 1948.

Index at acceptance:—**Classes 4,** G8; **and 108(iii),** I1, L1a2, M1(a: b), M2a.

COMPLETE SPECIFICATION

Improvements in or relating to Shock Struts

We, THE FIRESTONE TIRE & RUBBER COMPANY, a corporation organized under the laws of the State of Ohio, United States of America, of Main Street and Cole Avenue, Akron, Ohio, United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates generally to shock struts, and more particularly it relates to shock struts employing the "air-spring" principle.

A primary object of the invention is to provide a shock strut without a packing gland, whereby difficulties of gland leakage and excessive friction are eliminated.

A further object of the invention resides in the provision of an improved shock strut particularly adapted for use on airplane landing gear wherein the strut operates both as a suspension member and as a shock absorbing member.

Another object is to provide an improved telescopic strut wherein both frictional engagement between the telescoping members and air compression therebetween is employed as shock absorbing means.

A further object is to provide improved valve mechanism in a telescopic strut.

Another object is to provide an improved pneumatically cushioned strut wherein a bellows-like chamber communicates with telescopically associated members in a manner wherein air compression within the telescopic members is accompanied with simultaneous compression of air in the bellows to produce improved cushioning characteristics of the device.

Still another object is to provide an airplane suspension and shock absorbing gear which is light in weight though rugged in construction, while completely eliminating the use of impact absorbing springs.

A still further object is to provide improved means for constraining telescopically associated strut members against relative rotation during operation of the device.

According to the invention there is provided an airplane landing gear strut including a cylinder and a hollow piston reciprocable therein, means limiting relative movement therebetween, valve means for controlling fluid flow through the head of said piston, a pneumatic bellows connected intermediate the outer wall of the piston and the outer wall of the cylinder to provide a chamber therebetween, fluid communication means between the bellows chamber and the interior of the piston, said communication means being in the form of apertures in the wall of said piston, said apertures being so located as to provide uninterrupted fluid communication means between the bellows and the interior of the piston during a complete reciprocatory action of said cylinder and piston, and a compressible fluid within the piston, cylinder and bellows, said fluid being maintained therein under a pressure greater than atmospheric.

In order that the invention may be clearly understood and readily carried into effect the same will now be described more fully with reference to the accompanying drawings in which:—

Fig. 1 is a side elevation of an airplane showing the present invention incorporated therein.

Fig. 2 is a section along line 2—2, Fig. 1.

Fig. 3 is a vertical section through one of the strut assemblies shown in Fig. 2.

Fig. 4 is an enlarged detail of the valve shown in Fig. 3.

Fig. 5 is a view along line 5—5, Fig. 6.

Fig. 6 shows in vertical section an airplane strut having an alternate embodiment of the invention incorporated therein.

Fig. 7 illustrates a method of positively connecting the telescopic members without restricting operation of the air spring.

Fig. 8 is a view taken along line 8—8, Fig. 7.

Fig. 9 is a vertical section through an

air spring strut showing an alternate embodiment of the invention.

Fig. 10 is an enlarged sectional detail of the valve mechanism of Fig. 9.

Fig. 11 is a view taken along line 11—11, Fig. 10.

Fig. 12 shows in fragmentary vertical section an alternate valve mechanism.

Fig. 13 is a section taken along line 13—13, Fig. 12.

Fig. 14 illustrates in vertical section, the distended and contracted position of the air spring and its associated telescopic members.

Fig. 15 is a vertical section through a strut having another embodiment of the invention incorporated therein, showing the valve in closed position as during the compression stroke.

Fig. 16 is an enlarged detail, in section, of the valve structure of Fig. 15, with the valve shown open.

Fig. 17 is taken along line 17—17, Fig. 16

Fig. 18 shows in fragmentary section the valve closed during the expansion stroke.

Like parts are identified by the same reference numerals throughout the specification.

Figs. 1 and 2 show an airplane, generically designated by reference numeral 10, having a landing gear including tubular struts 11 and 12 carrying wheels 13 and 14, respectively and provided with air spring bellows 17 and 18. A horizontal bar 19 connects the upper ends of the struts, and streamlined housings or " pants " 20, enclose each strut and extend partially over each wheel. Bar 19 is fixed to rigid fuselage frame elements 21. The upper ends of struts 11 and 12 are fixed to the ends of bar 19, preferably by welding, the struts extending downwardly and diagonally outwardly as shown in Figs. 2 and 3

Referring to Fig. 3, strut 12 includes a lower tubular member 24, and an upper tubular member 25 of reduced diameter, partially disposed within member 24 in telescopic relation thereto. Members 24 and 25 are elliptical in cross section as shown in Fig. 11 to prevent relative rotation therebetween.

The bellows-like air spring 18 has its end margins clampingly engaged with members 24 and 25 respectively, as later described. The lower end of member 24 carries a closure member 29, welded thereto for the mounting of wheel 14 on axle 30 which is removably clamped to the member by nut 31 as shown.

As best shown in Fig. 4, the lower end of member 25 is provided with a valve assembly 32 providing a restrictive closure therefore. The assembly includes a cup-shaped closure cap 33 having a side wall 34 provided with a band of friction material for engagement with the inner wall surface of member 24, the friction material comprising a layer of square woven fabric 35, impregnated with oil and graphite, and a layer of rubber 36 forming a resilient backing therefor and bonded to the wall 34. The graphite and oil impregnated fabric snuggly engages the inner wall of member 24 to serve the duo-function of providing a pneumatic seal between the telescopically related members and providing frictional resistance to relative axial movement therebetween.

The above described frictional material produces an appreciable friction load. The diagonal positioning of the strut as shown increases the frictional effect. The static co-efficient of friction of the material used is approximately .16 while the dynamic co-efficient is approximately .52, whereby energy absorption will increase with rapidity of wheel movements. The energy absorbed by friction will be dissipated as heat from the strut, hence it will not recur in the succeeding recoil movement.

The upper end of member 24 is provided internally with a band 38 of the above described friction material, bonded to a metallic sleeve 39 which is preferably welded to member 24. Band 38 has its graphite and oil impregnated fabric engaging the outer wall surface of member 25 in pneumatic sealing and frictional contact therewith, whereby the telescopic members are maintained in proper alignment for relative axial movement which is opposed by the sealing material.

Valve assembly 32 includes a centrally apertured plug 40, welded at 41 to the end margins in member 25, the lower end of the plug abutting the inner end wall of cup 33. A disc-like member 42 is clamped to the outer wall of the cup by cap screws 43 extending through said wall to engage the plug 40. Disc 42 is spool-like with a concave periphery providing an annular channel 44 in which a floating ring 45, later described, is disposed. Disc 42 has a removable center plug 42a ported at 42b and provided with a check valve 46 for the control of fluid flow through the port during operation of the device. Valve 46 is of the flat disc type, movement of the disc being limited to the space within a cage-like guideway 47 comprising an integral extension of plug 42a. Plug 42a threadedly engages disc 42 and is constrained against removal by nut 48. Disc 49 has a depending rubber bumper 50 vulcanized

thereto, the disc being centrally clamped between nut 48 and disc 42. Bumper 50 is adapted to contact closure 29 during compression of the strut to cushion the contact between tubular members 24 and 25 under heavy shock conditions.

Ring 45 comprises a rubber annulus 54 moulded about metal reinforcement rings 55, annulus 54 having a peripherally applied graphite impregnated fabric band 56 in frictional engagement with the inner wall of tube 24. The fabric is maintained under a slightly expansive bias resulting from the metal reinforcements 55 being maintained within member 24 under slight contraction. The inner wall of annulus 54 is convexly arcuate and is of somewhat smaller diameter than the outer diameter of disc 42, whereby the disc loosely retains the ring during reciprocation of the tube 24 in respect to tube 25, the ring alternately engaging opposing wall portions of the dished outer wall of disc 42 later described.

During landing, impacts between wheel 14 and the ground cause tube 24 to slide upwardly over tube 25 against the opposition to such movement by frictional material 35 and 38, above described, and against resistance to air compression as later described. While the strut is adapted to operate with air under pressure, other gases may be used. Ring 45 is moved into sealing engagement with disc 42 along the upper wall of chamber 44 by reason of the engagement between frictional material 56 of ring 45 and inner wall of tube 24. Movement of ring 45 into the position described closes ports 59 to prevent air flow through ports 58 between the interior of tube 24 and interior of tube 25 except as controlled by the flow through the orifice 42b, check valve 46 being maintained open during the uptake. When the strut is allowed to expand, tube 24 moving in a downward direction, ring 45 moves downward to contact dished wall portion of disc 42. In this position of ring 45, air may flow from the interior of member 25 through ports 58 and 59 through chamber 44, and through notches 62 to the interior of tube 24. During expansion, the ring is maintained against the lower sidewall portion of the disc 42 by reason of the frictional engagement between the outer ring wall and the inner wall of tube 24.

The fluid flow control means disposed intermediate the interiors of the telescopically disposed tubes regulates air compression within both tube interiors, the compression within tube 24 being substantially greater during impacts than is the compression within tube 25, the air pressure in each tube, however, being quickly equalized. The upper end of tube 25 is plugged at 65 and is provided at 66 with apertures leading into the air spring bellows 18 which has an upper end 68 clamped in sealing engagement with a flange 69 mounted on tube 25, and a lower end portion 70 clamped to flange 71 in sealing engagement with tube 24.

Air spring 18 comprises a tubular wall 72 of rubber and fabric construction which may be substantially identical with the air spring bellows described in British Patents Nos. 517,986 and 520,222. The bellows wall 72 comprises upper and lower inter-connected annular chambers and is provided substantially midway between its ends with an externally applied girdle 73 of split ring form in cross section, said girdle being floatably carried during operation to maintain the air spring wall in a position to define plural chambers.

Referring to Figs. 5 and 6 there is shown a construction which is the same as that of Figs. 3 and 4, except that in the construction shown in Figs. 5 and 6 the lower end of the lower member of the telescoping members of the strut illustrates another arrangement by which a wheel may be carried by the strut. Thus in Figs. 5 and 6 strut 12c includes a lower tubular member 24c, and an upper tubular member 25c of reduced diameter, partially disposed within member 24c in telescopic relation thereto. Members 24c and 25c are elliptical in cross section as shown in Fig. 11 to prevent rotation therebetween.

The bellows-like air spring 18c has its end margins clampingly engaged with members 24c and 25c respectively. The lower end of member 25c is provided with valve means 32c and the lower end of member 24c carries a closure member 29c welded thereto and carrying a wheel 14c on an axle 30c mounted in the lower end of an offset, or cantilever, arm 115, which is attached to the closure member 29c and the lower end of the strut 24c in any manner found satisfactory, as by welding.

A scissors-like connector device 75, Figs. 7, 8 and 14, pivotably engages flanges 69 and 71 to limit the extent of travel between the tubular members, the position of the bellows wall during maximum contraction of the strut, being shown in dotted lines. The air cushioning actions employed herein are identical with the actions fully illustrated in the above mentioned British patents. Hence, operational characteristics will not be repeated in detail herein. It will be understood, however, that the air spring bellows operates both as a spring cushioning means and as a shock absorption means.

The strut is adapted to normally operate

between a distended position as shown in heavy lines, Fig. 14, and a contracted position as shown in dotted lines, reference hereinafter being made to the expansion stroke and the compression stroke, respectively. Extension between telescopic members 24 and 25 is normally limited by the maximum elongation of the bellows. Scissors 75 provide protective means in case of damage to the bellows resulting in their failure to positively connect the tubular members 24 and 25. The scissors include arms 80 and 81 pivoted to flange 69 at 82 and to flange 71 at 83, the arms having their opposite ends pivotally connected at 84. The pivots at 82, 83 and 84 may be restrictive to prevent scissors 75 from opening beyond the position shown in Fig. 14 thereby preventing undue strain on the air spring bellows 67 during operation of the strut, if desired.

The device operates at an air pressure considerably higher than atmospheric. An inflation valve, disposed at the rear of the strut as viewed in Fig. 3, communicates with the interior of the tube 24 through passage 86. Pneumatic pressure is applied through the inflation valve, the entire strut providing a closed pressure-tight unit inflatable to a degree determined in practice by the magnitude of the load carried thereby. Inflation is made from a source of supply of clean air, which is preferably dehydrated if the airplane to which the strut is attached is to fly at high altitudes. The provision of dehydrated air eliminates the possibility of moisture condensation, which at temperature below freezing is apt to result in the strut being rendered less efficient or inoperative. In actual practice air pressure is applied from a source not exceeding 100 pounds pe square inch until the strut lifts the plane two to four inches above the fully deflated position.

An alternative embodiment of the invention is shown in Fig. 9 wherein telescopically joined strut members 24a and 25a have connected therebetween the bellows 18a, the bellows having a medial region constricted by a girdle 73a including a cylindrical inner wall 87 and a pair of symmetrical outwardly extending transversely dished walls 88 and 89, the walls being joined along their outer-most margins. At maximum compression of the strut members, the bellows assume the position shown in dotted lines, Fig. 9.

The inner strut members 25a of the embodiment of Fig. 9 is provided at its lower end with valve means differing from the above described valve means of Figs. 3 and 4 primarily through the provision of a spring biased plug valve to limit pneumatic flow intermediate the chambers during the compression stroke in place the orifice valve accomplishing this function in the initial embodiment. Air flow through an orifice type valve is an arithmetical function of the speed of member 24, operating in member 25 as a piston whereas air flow through the spring biased valve is a geometric function of piston speed, until the valve is completely open, the valve operating as an orifice valve at speeds thereabove.

The spring biased valve means comprises an assembly 32a forming a lower end closure for strut member 25a. Assembly 32a, as best shown in Fig. 10, includes plates 90 and 91 mounted inwardly of member 25a, preferably by being welded thereto. Plate 90 includes a centrally disposed vertical sleeve portion 92 for reception of a plug valve 95 which is maintained under a downward urge by a compression spring 96 intermediate the head of valve 95 and a retainer cap 97 which provides an upper bearing for the stem of valve 95. Plate 91 is provided with a central port 100 and an adjacent valve seat portion for the engagement of valve 95 therewith. Disc type check valves 102 prohibit air passage through the strut connecting ports 103 during the compression stroke while allowing air passage there through during the expansion stroke. In common with the valve structure disclosed in Figs. 3 and 4, relatively free air passage is allowed between the telescopic strut members during the expansion stroke, the passage therebetween being substantially restricted by the centrally disposed valve during the compression stroke. A metallic cap 105 is clamped to the lower end of member 25a by cap screws 106, the cap having a central port 107 aligned with the central port 100 of plate 91, and plural radially extending ports 108 leading therefrom to a check valve 102. The lower end of member 25a has peripherally applied friction material, heretofore described, with its outer surfaces engaging the inner wall of member 24a as described in connection with embodiments of Figs. 3 and 4. A rubber bumper 109 (Fig. 9) is mounted on closure 29a in a position for cushioning engagement of cap 105 therewith during maximum compression of the telescopic members.

Another embodiment of the invention is shown in Figs. 12 and 13 wherein a valve structure, 32b is provided with a centrally disposed spring biased valve 110 and a floating ring 111 adapted to provide check valve means in a manner heretofore described. Valve 110 operates in the following manner.

During a slow compression stroke the air compressed within the lower strut chamber flows through slots 112 into the chamber 113 and upwardly through orifice 114 and port 115 to enter the upper chamber. If the air compression within the lower chamber is sufficient to move piston 116 upwardly against the urge of compression spring 117, a much larger volume of air escapes between the lower piston wall and the valve seat to flow through apertures 120 into the upper chamber. In this manner the rate of pressure equalization between the upper and lower strut chambers varies, within limits, in proportion to pressure differential therebetween during the compression stroke. Within limits, the greater the pressure differential between the lower and upper chambers, the greater will be the communicating passage therebetween since the compression of the spring 117 is proportional to said pressure differential.

During the compression stroke the upper wall of ring 111 effectively seals the entrance to multiple ports 58b, but during the expansion stroke the ring moves into engagement with the opposite wall 118 of its retaining channel and to permit air to flow freely between the strut chambers during the expansion stroke, a plurality of circumferentially spaced passageways 119 are provided in said lower wall, each passageway leading from an inner wall area diagonally outwardly to communicate with the lower chamber.

Figs. 15, 16, 17 and 18 show an alternative embodiment of the invention wherein the inner tubular member of the strut is provided with a piston type valve to permit air flow between the telescoping members only when the ring 45d is intermediate the end walls 123 and 124 of channel 121. In this embodiment, the upper end of the fixed strut members 25d is closed, no fluid passage being provided between the interior of member 25d and the bellows 18d except through a path which includes the annular channel 138 defined between the spaced telescopic strut members and plural circumferentially spaced ports 136 connecting the channel with the bellows.

As best shown in Fig. 16, the lower end of the strut member 25d carries a valve assembly 32d providing a restricted closure therefor. Assembly 32d comprises a plug 40d, centrally chambered at 130, and provided with an outwardly open circumferential channel 121 in which the sealing ring 45d is floatably disposed. Plug 40d has an upper portion extending into strut member 25d and welded thereto at 41d, with the chamber 121 below the end of the strut. The bumper 50d is clamped by stud bolt 48d to the lower end of plug 40d, bolt 48d threadedly engaging the lower plug end.

Floating ring 45d sealingly engages the inner wall of member 24d, the ring being provided with peripherally applied friction material 56d as above described. A brass sleeve 135 provides an inner ring surface engageable with the inner wall of channel 121 to present frictional contact therewith of substantially less magnitude than the frictional contact between material 56d and strut member 24d, hence the ring is moved by the strut within limits defined by channel 121. Ring 45d is of less width than channel 121 whereby during relative reciprocation of the strut members, the ring is reciprocated within the channel between valve closed positions of engagement with the upper channel wall 123 and the lower channel wall 124. The body of ring 45d is made up largely of rubber-like material moulded about an annular metallic reinforcing member 125, the ring being provided at the lower side of the reinforcing member with a plurality of radially extending fluid transfer ports 126, circumferentially spaced, and at the upper side with a plurality of radially extending circumferentially spaced ports 127. Ports 126 and ports 127 fall respectively in planes radially disposed respecting the axis of strut member 25d, the planes being axially spaced in respect thereto. The central portion of plug 40d is provided with a plurality of radially extending ports 128 connecting channel 121 with chamber 130. Ports 128 have their outer ends interconnected by a circumferential channel. During the compression stroke ring 45d is maintained in a valve closed position against upper channel wall 123, due to the difference in friction between material 56d and sleeve 135 as above described. During the expansion stroke the ring is maintained in a valve closing position against the lower channel wall 124 due to reversal of relative movement between members 24d and 25d.

As the compression motion ceases and the extension motion is initiated, the valve control ring 45d moves momentarily by friction, into the valve opening position shown in Fig. 16, with radially disposed ring ports 127 aligned with radial plug ports 128 and ring ports 126 aligned with plug ports 132, thus enabling pressure equalization between the bellows, the reservoir constituting the interiors of the members 24d and 25d, and the annular chamber between the ends of said members. Thus in the present embodiment, valve assembly 32d positively controls fluid communication between the bellows and the reservoir constituting the space

interiorly of the strut members, and also controls fluid flow from one telescoped member to the other. This construction permits maximum damping or shock absorber action, of which the air spring bellows reservoir system is capable. If desired to limit the damping to less than the maximum, cap screw 48d may be provided with an axial bore constituting a fixed orifice between the tubular members as illustrated in Fig. 15. Since the bellows and the strut members are connected only momentarily at the end of each stroke as ported ring 45d traverses the port section of plug 40d, the performance of the device can be altered by varying the size of ports 128 and 132, or conversely varying the size of the ring ports 126 and 127. The present strut has an added advantage in that the employment of strut members, elliptical in cross section to prevent relative rotaion and with friction material disposed therebetween, eliminates the necessity for accurate machining of the telescoped members. The elimination of a packing gland is also a highly desirable feature since gland leakage has been very common in telescopic struts adapted to be either hydraulically or pneumatically cushioned. The above described structure automatically equalizes the pressures in the bellows and in the tubular members irrespective of the temporary position of compression of the bellows. In other words automatic pressure equalization therebetween may take place when conditions cause stroke reversal release of the relative position of the tubular strut members at such time.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. An airplane landing gear strut including a cylinder and a hollow piston reciprocable therein, means limiting relative movement therebetween, valve means for controlling fluid flow through the head of said piston, a pneumatic bellows connected intermediate the outer wall of the piston and the outer wall of the cylinder to provide a chamber therebetween, fluid communication means between the bellows chamber and the interior of the piston, said communication means being in the form of apertures in the wall of said piston, said apertures being so located as to provide uninterrupted fluid communication means between the bellows and the interior of the piston during a complete reciprocatory action of said cylinder and piston, and a compressible fluid within the piston, cylinder and bellows, said fluid being maintained therein under a pressure greater than atmospheric.

2. A strut according to claim 1, in which the fluid flow between the telescoping members through the valve means of the piston is substantially greater during the expansion stroke than during the compression stroke.

3. A strut according to claim 1 or 2, in which the valve means is adapted to momentarily allow fluid pressure equalization between the bellows and interiors of the telescoping members upon reversal of the direction of relative movement between the members, and to prevent, or substantially prevent fluid flow therebetween during the compression and expansion strokes.

4. A strut according to any one of the preceding claims, in which the pneumatic bellows connects one end of one member to the other member intermediate the end thereof to provide a fluid reservoir for the members, and a safety link is pivotally secured between the members to limit the relative elongation thereof.

5. A strut according to claim 4, in which the safety link comprises a pair of lever arms, each arm having an end pivoted to one of the telescoping members, the opposite ends of the arms being mutually pivotally engaged to provide a scissors-like connecting link.

6. A strut according to any one of the preceding claims, having friction means carried by at least one of the telescoping members to oppose telescopic movement therebetween, the friction means having a dynamic co-efficient of friction substantially greater than its static co-efficient of friction.

7. A strut according to claim 6, in which the friction means comprises an element of graphite-impregnated fabric applied to one of the telescoping members to frictionally engage the other member.

8. A strut according to any one of the preceding claims, in which the piston has its outer wall portion provided with an annular channel, a ring disposed within the said channel with the outer wall thereof engaging the cylinder, and at least one passageway leading through the piston adjacent the ring, said passageway being adapted to be closed by the ring during movement of the piston in one direction within the cylinder and to be maintained open during movement of the piston in the opposite direction.

9. A strut according to any one of the preceding claims, in which the piston has a constricted end portion provided with a centrally disposed port including a valve seat portion with which a spring-biased plug valve is normally engaged, said valve plug being adapted to open under in-

creased fluid pressure during the compression stroke, and a second port leads through the piston and is provided with an associated check valve adapted to open during the expansion stroke and allow a fluid flow through the piston, and is adapted to prohibit flow therebetween during the compression stroke.

10. A strut according to any one of the preceding claims in which the valve means comprises a closure, the piston being provided with a centrally disposed port extending therethrough and a plurality of ports radially spaced from said central port and communicating therewith, the central port being normally closed by a spring-urged valve adapted to open as the result of fluid pressure build-up on one side of the closure, the radially disposed ports being provided with disc type check valves adapted to close the ports during the above described pressure build-ups to prevent fluid flow through the ports, and to open and allow fluid flow through the ports as the result of pressure build-up on the opposite side of the closure.

11. A strut according to any one of the preceding claims, in which the telescoping members are elliptical in cross section, and the bellows is disposed externally of said members and has one end sealingly engaging the piston near the upper end thereof and an opposite end sealingly engaging the piston near the upper end thereof and an opposite end sealingly engaging the upper end of the cylinder, the bellows is formed of resilient walls of fabric and rubber of annular form and has a medial region constricted by means of a floating girth ring, and fluid communication means is provided intermediate the interior of the piston and the space defined by the outer wall of the piston and the inner wall of the bellows.

12. A strut according to any one of the preceding claims, in which the piston has a ported closure plug provided with an orifice for the restricted flow of fluid therethrough, the plug has a portion extending below the piston, said portion being provided with an outwardly open circumferential channel, radially spaced ports extending from the channel through the plug to the interior of the piston, and a ring disposed within the channel, said ring having a peripheral surface engageable with the cylinder and being adapted to reciprocate axially within the channel during reciprocation of the piston in respect to the cylinder, the ring having a radially disposed port with an outer end leading into the space between the telescoping members and a radially disposed port having an outer end leading into the interior of the cylinder laterally of the plug, the inner ends of the radial ports being adapted for alignment with the plug ports during movement of the piston in one direction to permit fluid flow through the ports, and adapted for non-alignment therewith during movement of the piston in opposite direction to prohibit fluid flow therethrough.

13. A strut according to claim 12, in which the ring is frictionally operable during reciprocation of the members to permit fluid flow between the cylinder, the interior of the piston and the bellows during the expansion stroke and to prevent fluid flow therebetween during the compression stroke, and the orifice permits substantially less fluid flow between the cylinder and the piston during both strokes.

14. The airplane landing struts substantially as hereinbefore described with reference to and as illustrated in Figures 1—8, 9—11, 12—14, or 15—18 of the accompanying drawings.

Dated the 10th day of May, 1943.

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Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1948.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies, price 1s. 0d. each (inland) 1s. 1d. (abroad) may be obtained.

Fig. 1.

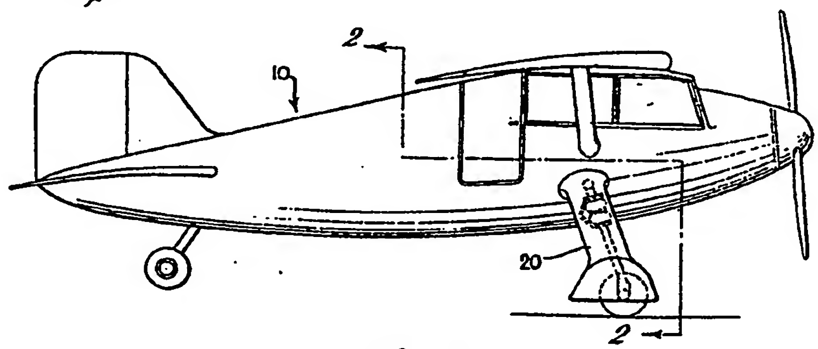
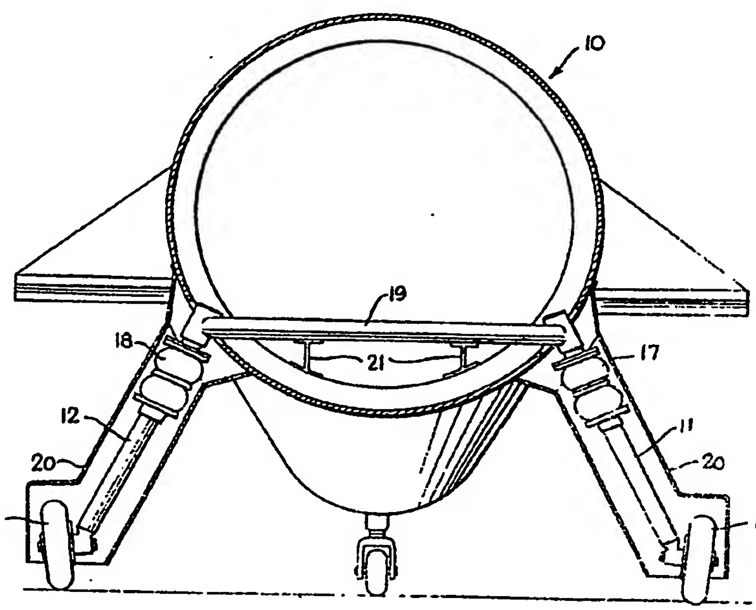


Fig. 2.

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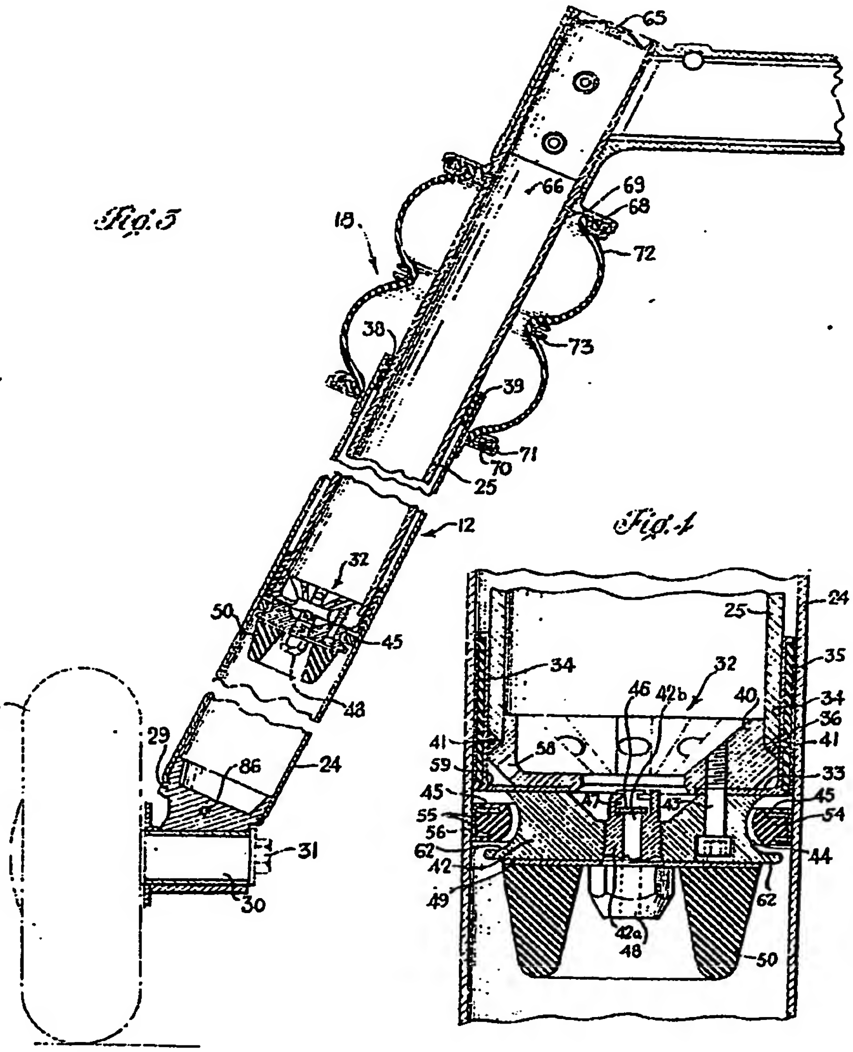
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Fig. 5

Fig. 4

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2 SHEETS SHEET 1

Fig. 1.

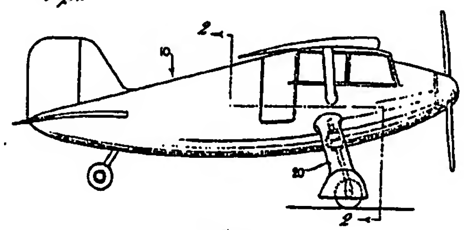

Fig. 2.

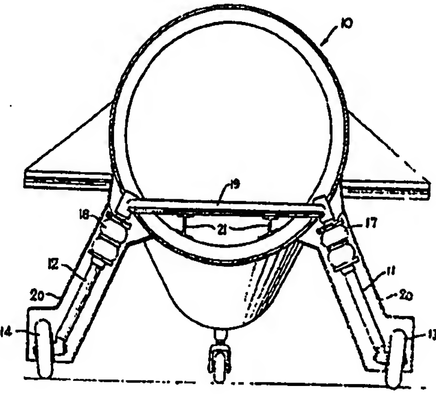

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Fig. 3

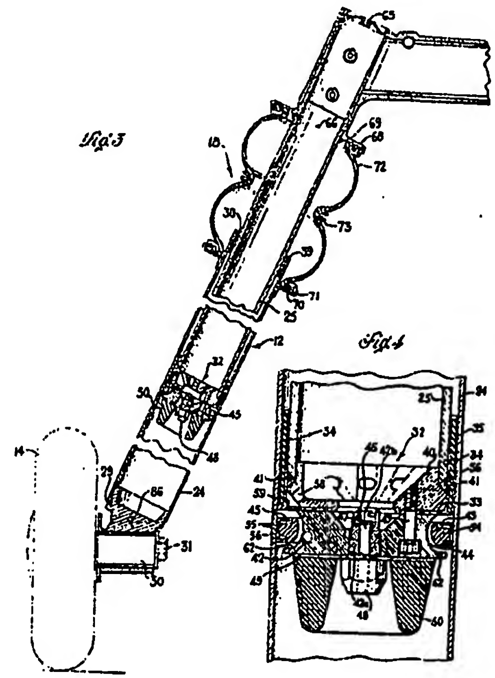

Fig. 4

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H.M.S.O. (Ty. P.)

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Fig. 6

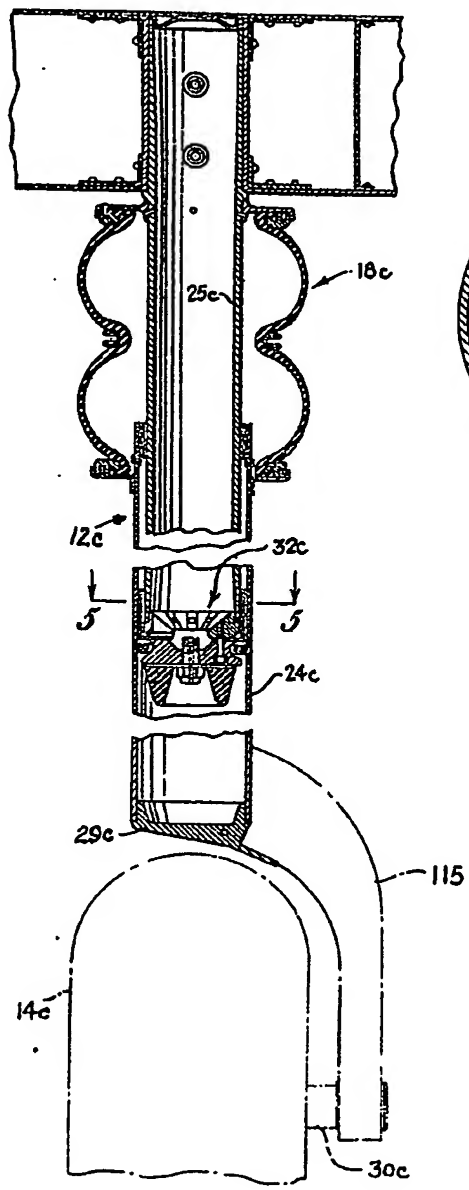
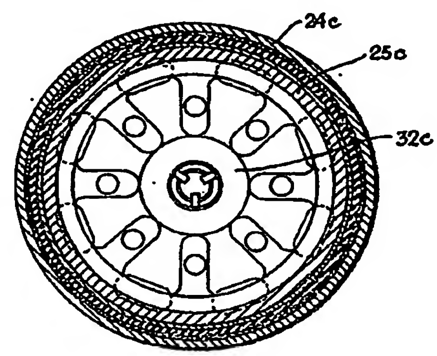


Fig. 5



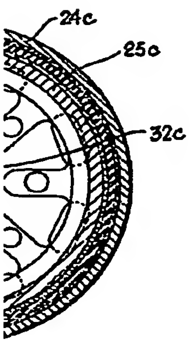


Fig. 7

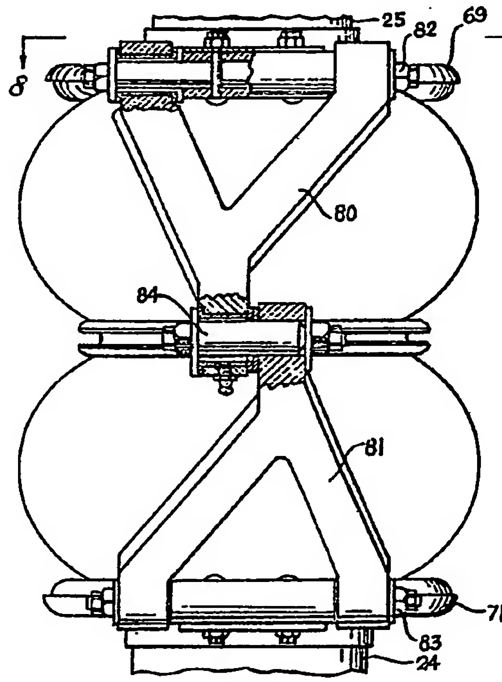


Fig. 8

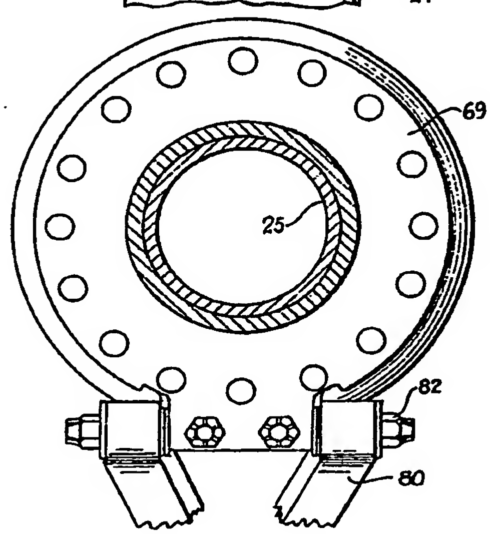


Fig. 6

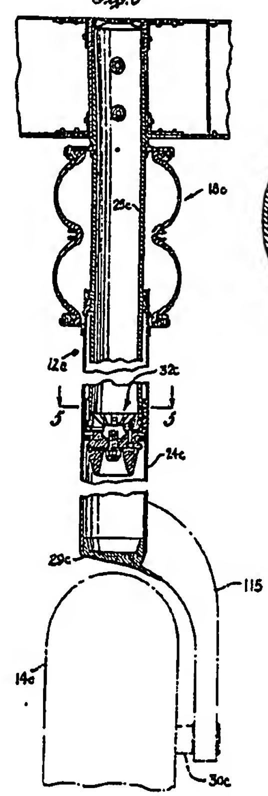
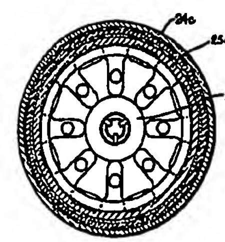


Fig. 5



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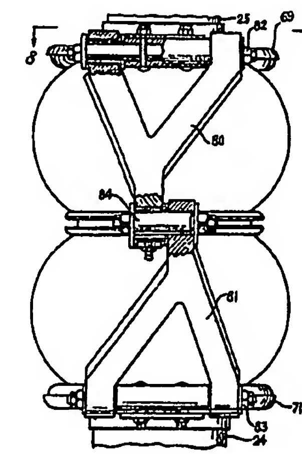

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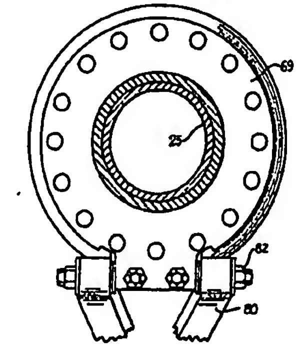

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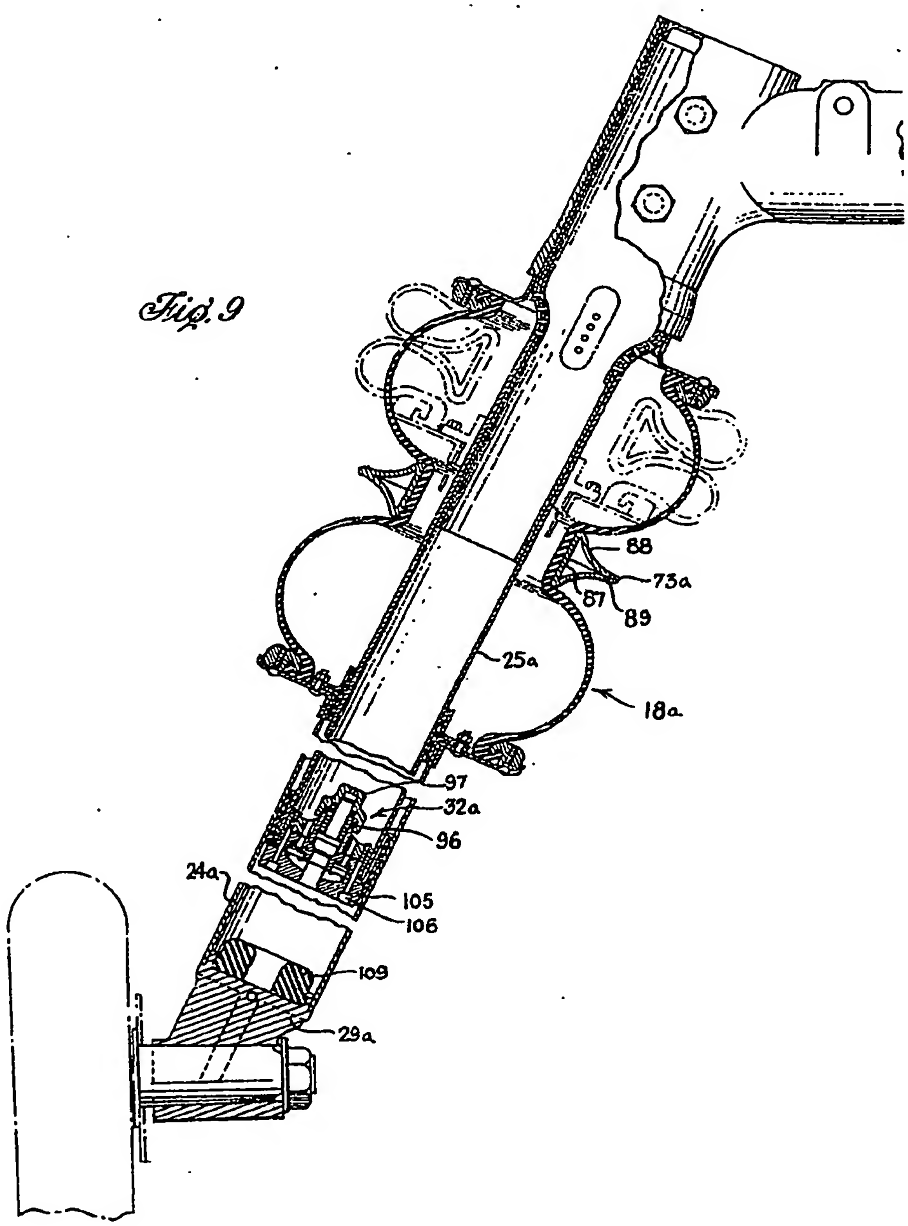
Fig. 9



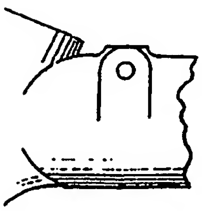
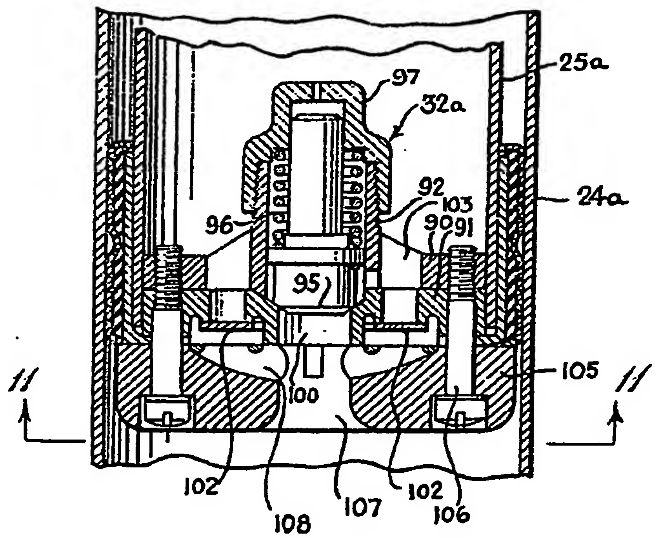


Fig 10


97
32a
25a
24a
92
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96
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11
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108
107
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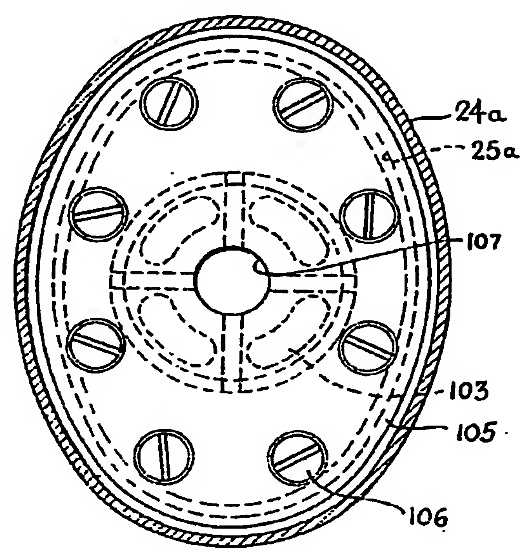
106

Fig 11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25a
107
103
105
106

Fig. 9

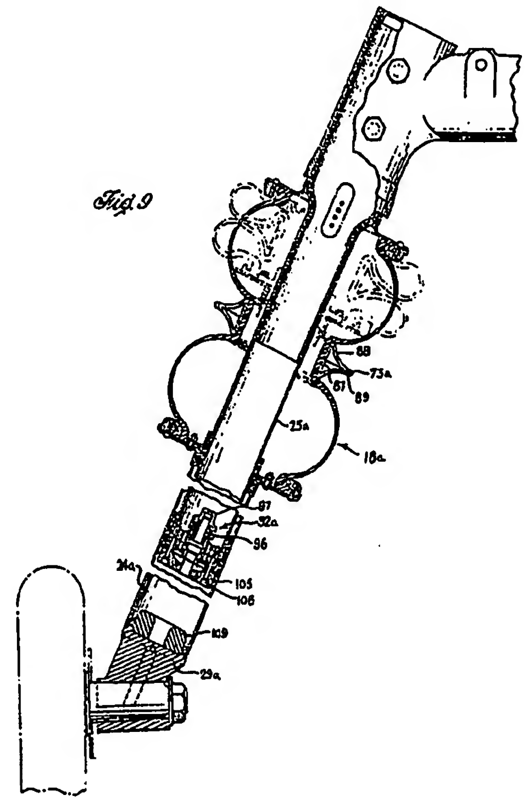

Fig. 10

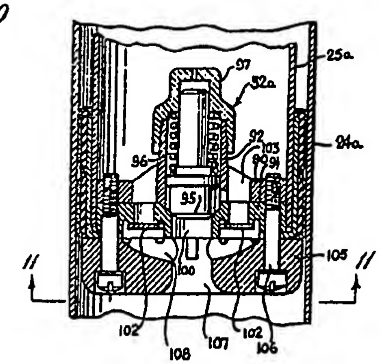

Fig. 11

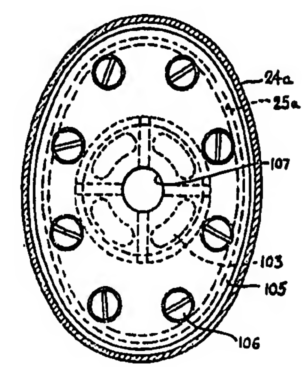

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Fig. 13

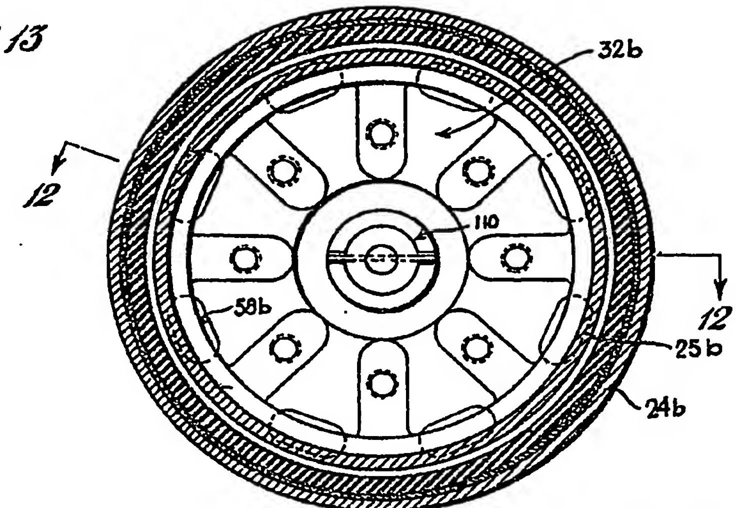
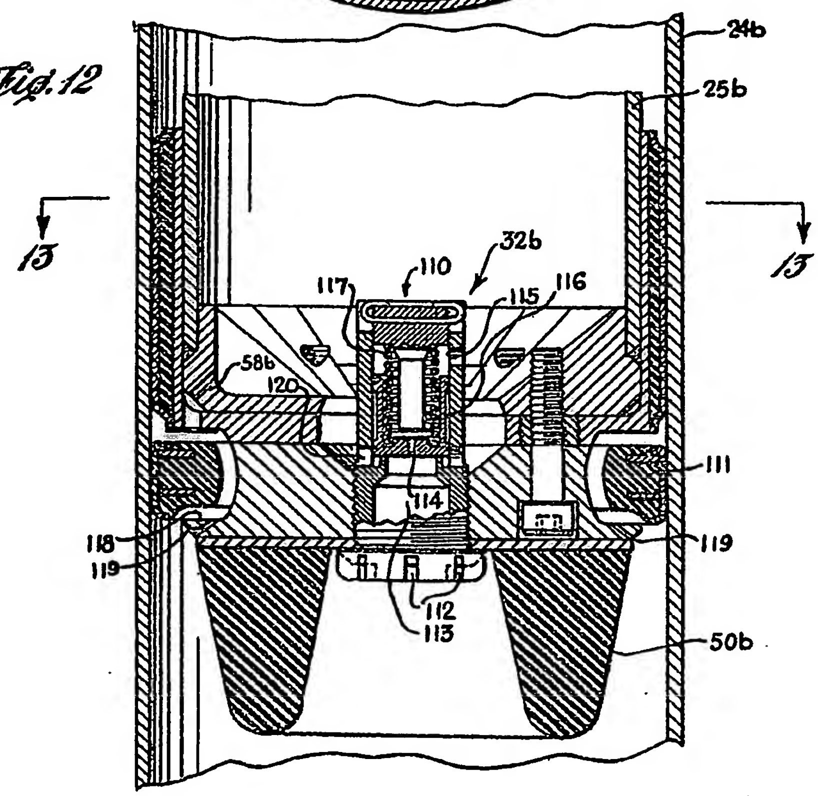


Fig. 12



SHEET 7

12
25 b
b
24b
25b
13
111
19
50b

Fig.14

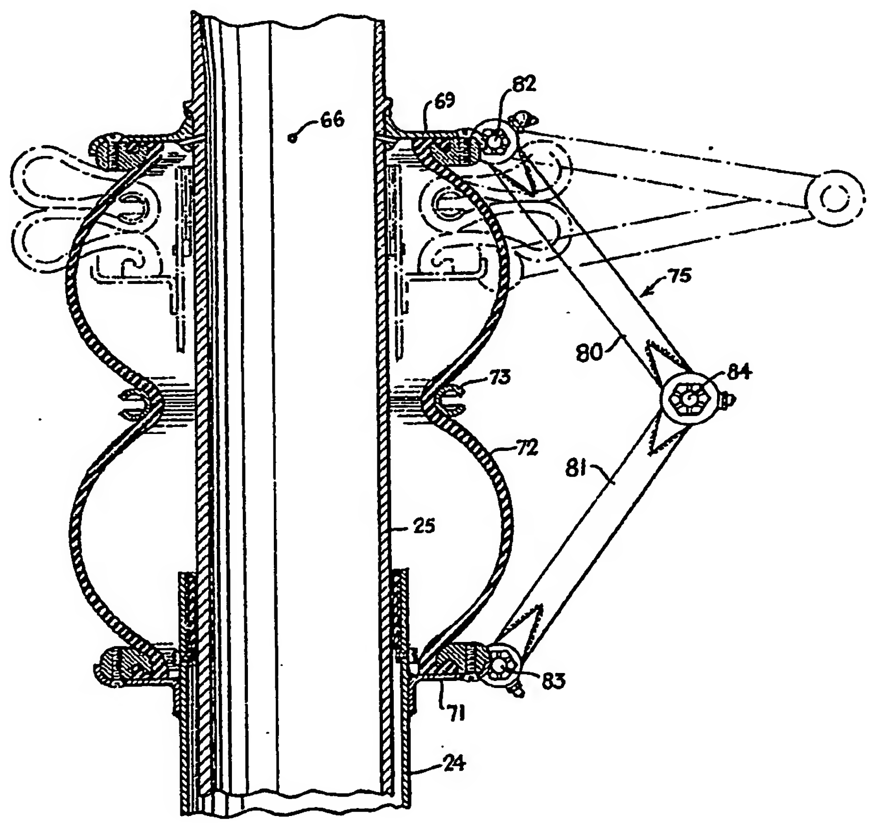


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Fig. 13

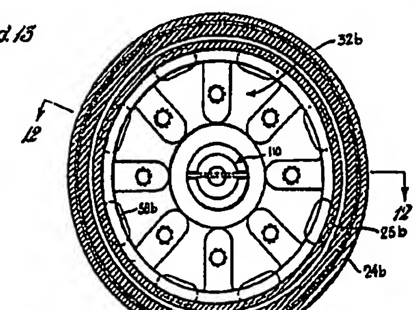


Fig. 12

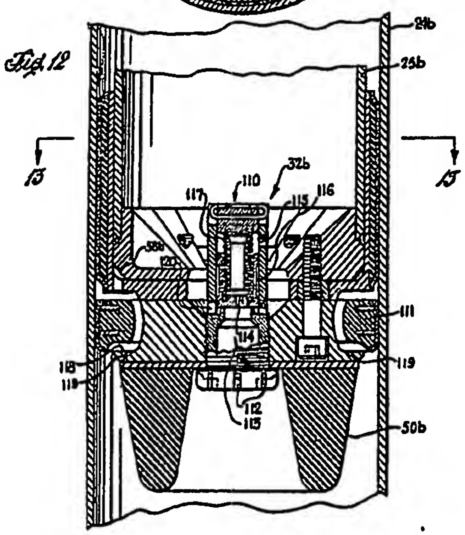
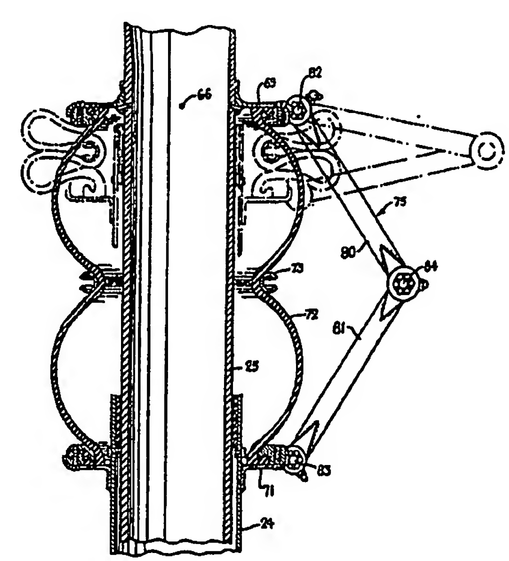


Fig. 14



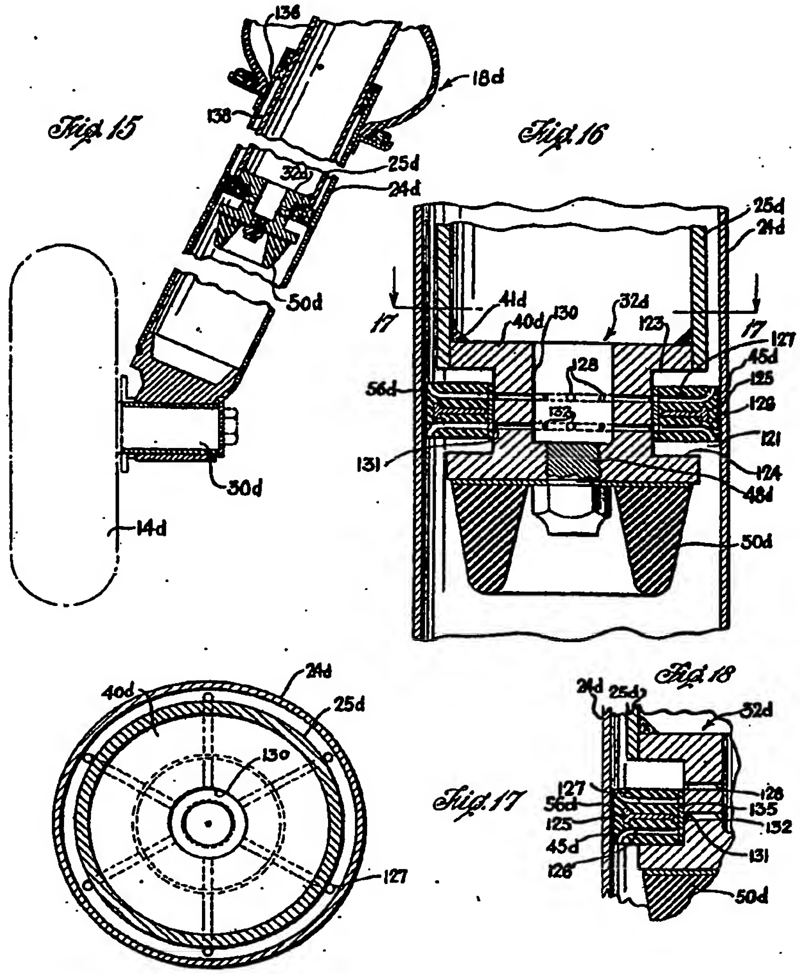


Fig. 15
136
138
18d
25d
32d
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50d
30d
14d
Fig. 16
25d
24d
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130
32d
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45d
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128
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131
124
48d
50d
24d
40d
25d
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127
Fig. 18
24d
25d
32d
Fig. 17
127
56d
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45d
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128
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132
131
50d

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